



Synthetic Vision and Pathway Depictions on the Primary Flight Display

Small Airplane Directorate Draft Advisory Circular

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Presentation Outline

- Draft AC for Part 23 (small airplanes)
 - Synthetic Vision Displays
 - Pathway Displays
- List 16 AC items and discuss the rational

Operational Concept for GA

No operational credit

- Can't reduce any minimums
- Have to follow IFR rules



Operational Concept for GA

So What Are The Benefits of Synthetic Vision?

- We have accidents in IMC that we don't have in VMC conditions
- Pilot workload, mental gymnastics, and opportunity to make mistakes – “the anxiety reduction” factor
- “IFR rating 5X harder than a private”

Pilot Evaluation

- There are hundreds of variables that can distinguish one display system from another.
- Because of the number of variables, we expect to use a multiple pilot evaluation for all new part 23 displays incorporating synthetic vision and pathway symbology to ensure that there are no unsafe features.
- Not all synthetic vision/pathway systems are necessarily safety improvements.
- The applicant's system must be shown to provide a level of safety at least equal to the conventional flight instruments it replaces.
- Evaluation questions will target specific information presented on the display, its intended function, and whether or not it is usable for flight tasks required by FAA's Flight Standards for typical instrument and commercial ratings.



Evaluation Criteria

The integration of synthetic terrain/vision and pathway imagery on the background of a PFD with HITS flight guidance are novel features for which the FAA does not have standards or guidance. Therefore, the display must be evaluated against the following:

- ☞ The primary flight display and synthetic terrain/vision meet its intended function; and,**
- ☞ The additional and/or novel features do not create an unsafe condition (i.e. level of safety at least equal to the conventional flight instruments).**

TAWS System

- Any airplane using an SV system, installed as part of the pilot's primary flight instrumentation, should also install a TAWS system approved to TSO 151b, Class A, B, or C. TAWS is considered a mitigating feature for a SV display's potential to mislead the pilot in several cases.

Airplane Reference Relative to Terrain

If terrain is displayed on the attitude indicator, the pilot should clearly be able to distinguish between terrain above and below the airplane

Heading Integrity

- Synthetic vision displays may use the airplane's heading to display terrain and all other features. Currently, the failure classification for heading in a typical GA installation is only major.
- Applicant's should consider a system architecture or equipment combination that allows easy identification of misleading terrain heading

Horizon Line

Dynamically changing terrain background shapes and edges may create the false sensation of changing attitude. Existing guidance recommends a solid, bold artificial horizon line extending across the entire display, representing a line that shows a projected level flight path.

Moving Map That Corresponds To And Compliments SV PFD Display

- When viewing the terrain on a limited field-of-view display the pilot may incorrectly infer the location of the aircraft relative to the terrain
- Unless the SV display is so good that correct depth perception is possible, a terrain map should be located adjacent to the PFD so the pilot has accurate distance relationships from terrain and obstacles
- Would prefer that this map is combined with your primary navigation display
- TAWS should be incorporated as part of this map display

Moving Map That Corresponds To And Compliments SV PFD Display



Failure Modes

- Failure modes of the terrain display should either be provided to the pilot or identified internally by the system before the pilot re-action to the display could become hazardous. Examples are the terrain failing in pitch, roll, and heading. The display should not cause the pilot to pitch or roll beyond safe limits before the failure is obvious to the pilot. (Safe limits might be +/- 15 deg. of pitch and 30 deg of roll.) Comparisons between the attitude display and the terrain system should flag failure modes and these failures must be investigated during the pilot evaluations.

Terrain Color and Depiction

- There are terrain coloring techniques that are effective in conveying terrain information to the pilot while making the separation between sky and ground obvious
- Shading, texturing, and shadowing techniques have proven effective in realistic terrain portrayal. However, for shadowing, light source (sun angle) positioning must be carefully controlled to avoid the obscuration of important terrain features by shadows.

Minimums Audio Callout Capability

- Pilots are more likely to follow 3-D flight guidance (like Highway-in-the-Sky) below minimums because of the display's compelling nature
- Applicants should incorporate a pilot selectable or automatic altitude alert with audio callout to remind the pilot they are approaching minimums

Obstacles, Traffic, and Airport Runway

- In addition to including synthetically drawn terrain on the PFD, applicants should include all obstacles over 200 ft.
- Another highly desirable feature is to depict the airport for the approach selected. The airport anchors the approach.
- One of the benefits of a 3-D display is that the pilot can see their relative position to important landmarks like the airport, terrain, and towers.

Obstacles, Traffic, and Airport Runway

- These features can easily be cross-referenced to published approach charts. Making all IFR approaches more visual meets our objective in approving new electronic displays – that is to reduce pilot workload.
- Using the same logic, cockpit display of traffic information should be available to the pilot somewhere on the system. While this information does not need to be on the PFD, traffic symbology on the primary navigation display or the map page will add to safety.

DEM Resolution

- The DEM resolution is one factor that determines how well the SV terrain depiction will match the actual terrain environment.
- Applicants should strive for a DEM resolution no worse than that of TAWS requirements
- NASA experiments showed that even though pilots preferred the higher terrain resolutions, 30 arc-second database would still be safer than the conventional round dial instrument panel.

Display Update Rates

The display needs to have a high enough update rate to provide smooth motion for all reasonable flight maneuvers appropriate for the class of airplane

Pathway boundaries

- Pathway boundaries or dimensions should be selected according to the type of guidance they are providing. There are almost as many difference pathway dimensions used in research as there are research projects.
- Previous Approval
 - Vertical limits for non-precision approaches are fixed at a minimum altitude, MDA, and are maintained by using the altimeter.
 - The important component of the pathways are the accompanying guidance for lateral and vertical limits.

Precision Approach Guidance

- Applicant's should consider overlaying precision approach guidance on the pathway
- Independent sensors should be used to generate the display symbology for visual redundancy
- One example of this implementation is to use GPS for the pathway depiction and ILS for the precision approach guidance

UNIVERSAL

Aircraft Flight Manual

- The flight manual supplement must contain reasonable limitations for the pilot concerning the appropriate use of the applicant's system and the limitations should be explained.
- Training Issues should be addressed in the AFM as well, particularly with regard to the proper use and potential mis-use of the display for terrain awareness and avoidance.
- The applicant should provide information describing how well the DEM represents the actual terrain.

TEST

-DIM+

Digital Elevation Model (DEM) Integrity

- Pilots may assume all information displayed on the PFD is equally valid
- The PFD is the most important display in the cockpit and requires the highest level of integrity for primary flight information
- Terrain database must be approved to the same standards as for TAWS systems
- Should meet the highest level of integrity in DO-200(*)

Open Issues For Discussion

1. Do **NOT** remove terrain display for unusual attitudes or TAWS warnings
2. Gap between the airplane 0° pitch line and terrain horizon. (HDD with HUD symbology)

Open Issues For Discussion

3. Autopilot integration – propose:
 - Nothing present on display, heading hold / wing leveler
 - If pathway present, A/P follows it laterally and vertically
 - Heading / Altitude bugs have priority over pathway
4. Open for any more issues...